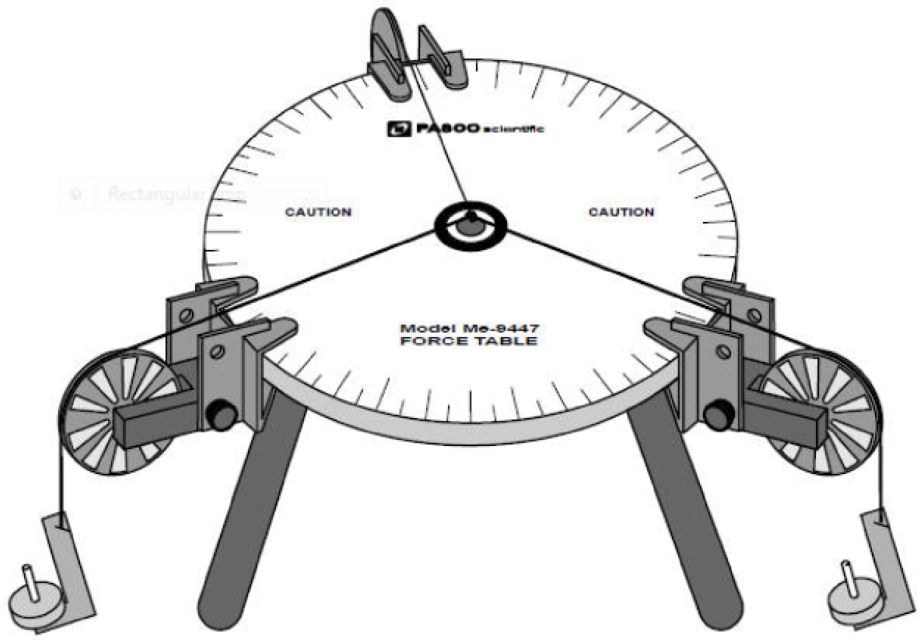
EXPERIMENT 9 : Force Vectors & Equilibrium



you also need a polar graph paper:

http://www.texample.net/tikz/examples/polar-coordinates-template/

Date: ___________________

Author: _________________________________

Partner: _________________________________

Partner: _________________________________

Equipment List:

• Force Table Apparatus (for example sargent welch (CP33862-00))
• Mass Hangers
• Small Laboratory Masses
• Ruler
• Protractor
• Graph Paper
• Unknown mass
• Gravity

Introduction:

Some physical quantities have only magnitude, as in the cases of mass, time, and density. These quantities are called scalars. The student is familiar with addition, subtraction, multiplication and division of scalars. Other physical quantities such as velocity, acceleration and force need to have a direction specified as well as a magnitude. These quantities are called vectors. The algebra of vectors is more sophisticated than the algebra of scalars. In this experiment, only two aspects of the algebra are studied, that of addition and subtraction of vectors. To be even more precise, we will study in this experiment only concurrent vectors (vectors which all pass through a single point at the same moment). The vector physical quantities, which we study here, are Forces.

Procedure:

1. Using the three pulleys, set up an equilibrium situation using three different masses, each within at least 10g of the other (for example, 100g, 120g, and 140g or 130g). So move the pulleys until you reach equilibrium. EQUILIBRIUM IS REACHED WHEN THE PIN DOES NOT TOUCH THE RING.
   Record the angular position of each string, along with the hanging weights (in g).

   THE MASS IS THE MAGITUDE OF THE FORCE AND THE ANGLE THE DIRECTION

String	Direction (Degrees)	Mass (g)
#1		
#2		
#3		

Note: usually the magnitude is in newtons = mass (in kg) x 9.8
but since the purpose of the goal is to study equilibrium is does not matter.
So we will just pretend that unit for force is g. (just a factor away)

2. Using a polar graph paper a, draw appropriately scaled down vectors (so 3 **arrows**) representing the three forces you created with the strings in Step 2. The length (or magnitude) of each arrow (or vector) represents the mass that is pulling the string. So make up a scale like 10cm = 100g . So for example, if the mass is 200g the length on the graph paper 20cm long. (divide by 10). You could also divide by 20 if the arrows don't fit on the paper.

On the same piece of graph paper (or on a second piece), add 2 of the vectors together graphically using the head-to-tail method or the parallelogram method.
SEE HERE to review adding vectors:
http://www.cabrillo.edu/~jmccullough/Applets/Flash/Mathematical%20Concepts/Add2Vectors.swf

Measure and record the magnitude and direction of the resultant.
Hint: use your ruler to find the length of the resultant and convert cm to grams to find the mass.
Read the direction on the polar graph paper.

Direction (Degrees)	Mass (g)

4. Compare to the third vector (arrow) :

third vector is:

Direction (Degrees)	Mass (g)

You should get the same magnitude ?
Do you get opposite direction ? (check on the polar graph)

THIS IS BECAUSE F1 + F2 + F3 = 0 (at equilibrium vectors cancel out)

or -F3 = F1 + F2

5. For each force F1, F2, F3 compute the x-component and the y-component :
Remember: x-component = F cos(..)   y-component= F sin(..)

	X-component	**Y-component**
F1		
F2		
F3		
Sum		

Add the x-components and the y-components.
Do you get about 0 ? (In theory, you should get 0 but because we introduce so much errors, you will a number around 5 or -5)

6. choose an object of unknown mass (ask instructor) that can easily hang from one of Force Table hangers. The unknown mass is by itself on its hanger. You can change the other masses to reach equilibrium.

To simplify the computation the string with the unknown mass is along the 0 degree. So its y-component =0 .

3. **Fill the table**

	X-component	**Y-component**
F1		
F2		
F3 (unknown)	?	0
Sum	0	0

7. Use sum(x-components) = 0 to find the unknown mass.

Mass = _________________- The sum of the y-components should be about 0.

Use a scale to find the true mass and compute the % error

8. When an equilibrium is reached, one can derive 2 equations. By doing :

Conclusion:

Discuss your results from each step, what results you ought to have seen, and the possible causes of any significant error that you may have seen.